



**BROOKHAVEN**  
NATIONAL LABORATORY

# NSRL-2 RUN

## FINAL REPORT

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**BNL/NASA webpage:**  
**<http://www.bnl.gov/medical/NASA/NASA-home%20frame.htm>**

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## EXECUTIVE SUMMARY

During the spring of 2003, a series of radiobiological and physics experiments were performed using the NASA Space Radiation Laboratory to deliver iron, carbon, silicon and titanium beams (NSRL-2). These experiments were part of the second NSRL run sponsored by NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program at BNL.

A total of 30 proposals were approved to participate in the NSRL-2 run. Seventeen institutions from the United States and 2 from foreign countries (Japan and England) were represented, totaling 82 users. More than 1700 biological samples were exposed at the NSRL beam line, employing 214 hours of beam time (83.5 hours for in vivo studies, 112 hours for in vitro studies and 18.5 hours for physics experiments. In addition, 19 hours were used for beam development and, 78.5 hours for set-up and dosimetry. A total of 17 hours of beam time were lost due to RHIC fillings and 53.5 hours were lost due to accelerator related problems.

NSRL-2 was the first run carried out alongside RHIC. There were several changes made to the way beam was extracted and scheduled at NSRL and the way access to the target room was provided. During NSRL-2, Booster provided iron (577 and 0.969 GeV/nucleon, LET: 176.1 and 151.1 keV/ $\mu$ m), Carbon (0.293 GeV/n, LET: 12.8 keV/ $\mu$ m), Titanium (0.980 GeV/n, LET: 108.1 keV/ $\mu$ m) and Silicon (580 GeV/n, LET: 53 keV/ $\mu$ m) ion beams for biology and physics experiments. The dose/rates used were as low as 0.1 cGy/min and as high as 2000 cGy/min. The spill rate employed was 20 for Fe, Si, Ti and C with duration of 400 msec/spill. The spill fluence was (particles/spill)  $3 \times 10^9$  (max) and 500 (min). Square beam spots as big as 20 x 20 cm and small as 1 x 1 cm was employed for biology and physics experiments.

Tandem-Booster set-up started on March 15 with the transport and circulation of Si beams at the NSRL complex. Beam was tuned into cave on March 15. 600 MeV/n Si beams were available for tuning on March 15. The next several shifts were spent on physics experiments (E. Benton). Biology studies started on the morning of March 16 using 600 MeV/n silicon beams (M. Vazquez, BNL) and proceeded through March 19. On March 22, AGS-Booster tuned 0.29 GeV/n carbon beams for biology studies ending on March 23. From March 24 to late March 26, NARL was not operational due to RHIC testing. On the late evening of March 26, AGS-Booster complex delivered iron ions 1 GeV/n for physics and biology. NSRL operations were interrupted many times in order to fill RHIC for physics experiments. This joint operations lasted from March 27 to April 1 making very difficult complete some of the biology and physics experiments. During the week of April 5-9, for the first time a fractionated in vivo experiment were accomplished at NSRL (P. Chang) requiring daily fractions for 5 consecutive days. Experiments using 1 GeV/n iron ions were completed on April 9. On April 12, 0.6 GeV/n iron beams were tuned for an extensive series of in vitro and in vivo experiments. On April 20, AGS-Booster complex delivered 1 GeV/n titanium beams for biology experiments running until late afternoon on November 22. NSRL-2 officially ended at 1900 pm, April 22, 2004.

**NSRL-2 Projects Reviewed by the BNL's Scientific Advisory Committee in Radiobiology (SACR):**

<b>Proposal</b>	<b>PI</b>	<b>Sponsor Agency</b>	<b>NSRL-2 Participation</b>
<b>B3</b>	<b>Cucinotta</b>	<b>NASA</b>	<b>Yes</b>
<b>B7</b>	<b>Rabin</b>	<b>NASA</b>	<b>Yes</b>
<b>B10</b>	<b>Chang</b>	<b>NSBRI</b>	<b>Yes</b>
<b>B44</b>	<b>Durante</b>	<b>ISA</b>	<b>No</b>
<b>B52</b>	<b>Gewirtz</b>	<b>NSBRI</b>	<b>Yes</b>
<b>B64</b>	<b>Vazquez</b>	<b>NSBRI</b>	<b>Yes</b>
<b>B65</b>	<b>Vazquez</b>	<b>NSBRI</b>	<b>Yes</b>
<b>B67</b>	<b>Blakely</b>	<b>NASA</b>	<b>Yes</b>
<b>B73</b>	<b>Sutherland</b>	<b>DOE/NASA</b>	<b>Yes</b>
<b>B75</b>	<b>Ford</b>	<b>DOE/NASA</b>	<b>Yes</b>
<b>B76/N76</b>	<b>Green</b>	<b>DOE/NASA</b>	<b>Yes</b>
<b>N86</b>	<b>Wang</b>	<b>NASA</b>	<b>Yes</b>
<b>N88</b>	<b>Sutherland</b>	<b>NASA</b>	<b>Yes</b>
<b>N89</b>	<b>Held</b>	<b>NASA</b>	<b>Yes</b>
<b>N91</b>	<b>Rydberg</b>	<b>NASA</b>	<b>Yes</b>
<b>N95</b>	<b>Story</b>	<b>NASA</b>	<b>Yes</b>
<b>N96</b>	<b>Nelson</b>	<b>NASA</b>	<b>Yes</b>
<b>N97</b>	<b>Kronenberg</b>	<b>NASA</b>	<b>Yes</b>
<b>N102</b>	<b>Hall</b>	<b>NASA</b>	<b>Yes</b>
<b>N104</b>	<b>Weil/Ullrich</b>	<b>NASA</b>	<b>Yes</b>
<b>N105</b>	<b>Chatterjee/Bedford</b>	<b>NASA</b>	<b>Yes</b>
<b>N106</b>	<b>Gatley</b>	<b>NASA</b>	<b>Yes</b>
<b>N107</b>	<b>Kennedy</b>	<b>NSBRI</b>	<b>Yes</b>
<b>N108</b>	<b>Pecaut</b>	<b>NASA</b>	<b>Yes</b>
<b>N109</b>	<b>Archambeau</b>	<b>NASA</b>	<b>Yes</b>
<b>N110</b>	<b>Nelson</b>	<b>NASA</b>	<b>Yes</b>
<b>N111</b>	<b>Obenaus</b>	<b>NASA</b>	<b>Yes</b>
<b>N112</b>	<b>Obenaus</b>	<b>NASA</b>	<b>Yes</b>
<b>N113</b>	<b>Pecaut</b>	<b>NASA</b>	<b>Yes</b>
<b>N116</b>	<b>Benton</b>	<b>NASA</b>	<b>Yes</b>

## **NSRL-2 PARTICIPANTS**

<b>Exp.</b>	<b>Participants</b>	<b>Affiliation</b>	<b>Title</b>
B-3	<b>F. Cucinotta</b> K. George H. Wu N. Desai P. O'Neill E. Davis	NASA, Johnson Space Center, TX " " " MRC Radiation & Genome Stability Unit, UK "	<b>Ph.D, Principal Investigator</b> Senior Research Associate Ph.D., Co-Worker B.S., Co-Worker Ph.D., Co-Principal Investigator Ph.D., Co-Worker
B-7	<b>B. Rabin</b> J. Joseph B. Shukitt-Hale	UMBC, Baltimore, MD HNRCA, USDA-ARS, Boston, MA "	<b>Ph.D, Principal Investigator</b> Ph.D., Co-Worker Ph.D., Co-Worker
B-10	<b>P. Chang</b> J. Bakke J. Orduna	SRI International, CA " "	<b>Ph.D, Principal Investigator</b> B.S., Co-Worker B.S., Co-Worker
B-52	<b>A.Gewirtz*</b> B. Sutherland P. Bennett M. Naidu D. Roy M. Hada J. Sutherland D. Monteleone J. Trunk	University of Penn. School of Medicine, PA BNL, Biology Dept., Upton, NY " " " " " " " "	<b>Ph.D, Principal Investigator</b> <b>Ph.D, Co-Principal Invest.</b> M.S., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker B.S., Co-Worker B.S., Co-Worker
B-64 B-65	<b>M. Vazquez</b> J. Gatley P. Guida S. Russell A. Billups M. Bruneus B. Pyatt L. Pena X. Lin K. Nojima	Brookhaven National Laboratory, NY " " " " " " " " " NIRS/HIMAC, Japan	<b>M.D, Ph.D, Principal Invest.</b> Ph.D, Co-Worker Ph.D, Co-Worker B.S., Co-Worker B.A., Co-Worker M.A., Co-Worker M.A., Co-Worker Ph.D, Co-Worker Ph.D, Co-Worker Ph.D, Co-Worker
B-67	<b>E. Blakely</b> P. Chang J. Bakke J. Orduna	LBNL, Berkeley, CA SRI International, Menlo Park, CA " "	<b>Ph.D, Principal Investigator</b> Ph.D., Co-Worker B.S., Co-Worker B.S., Co-Worker
B-75	<b>J. Ford</b> L. Braby E. Maslowski	Texas A&M Univ., College Station, TX " "	<b>Ph.D, Principal Investigator</b> <b>Ph.D, Co-Principal Invest.</b> Ph.D, Co-Worker
B-73 N-88	<b>B.Sutherland</b> P. Bennett M. Naidu D. Roy M. Hada P. Kumar J. Sutherland G. Ming D. Monteleone J. Trunk N. Cuomo	Brookhaven National Laboratory, NY " " " " " " " " " " "	<b>Ph.D, Principal Investigator</b> M.S., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker B.S., Co-Worker B.S., Co-Worker B.S., Co-Worker

<b>Exp.</b>	<b>Participants</b>	<b>Affiliation</b>	<b>Title</b>
B-76	<b>L. Green</b> B. Bianski	Loma Linda University, CA “	<b>Ph.D, Principal Investigator</b> Ph.D., Co-Worker
N-86	<b>Y. Wang</b> H. Wang	Thomas Jefferson University, PA “	<b>Ph.D, Principal Investigator</b> B.S., Co-Worker
N-91	<b>B.Rydberg*</b> T. Groesser B. Cooper	LBNL, Berkeley, CA “ “	<b>Ph.D, Principal Investigator</b> B.S., Co-Worker B.S., Co-Worker
N-96	<b>G. Nelson</b> T. Jones A. Smith S. Rightnar C. Perez	Loma Linda University, CA “ “ “ “	<b>Ph.D, Principal Investigator</b> B.S., Co-Worker B.S., Co-Worker B.S., Co-Worker B.S., Co-Worker
N-97	<b>A. Kronenberg</b> S. Gauny L. Connolly M. Turker	LBNL, Berkeley, CA “ Oregon Health and Science University, OR “	<b>Sc.D, Principal Investigator</b> M.S., Co-Worker B.S., Co-Worker Ph.D., Co-Worker
N-102	<b>E. Hall*</b> L. Smilenov R. Baker	Columbia University, NY “ “	<b>Ph.D, Principal Investigator</b> Ph.D., Co-Worker Ph.D., Co-Worker
N-104	<b>M. Weil</b> R. Ullrich	Colorado State University, CO “	<b>Ph.D, Principal Investigator</b> <b>Ph.D., Co-Principal Investigator</b>
N-105	<b>A. Chatterjee*</b> J. Bedford P. Wilson	LBNL, Berkeley, CA Colorado State University, CO “	<b>Ph.D, Principal Investigator</b> <b>Ph.D, Co-Principal Investigator</b> B.S., B.A., Co-Worker
N-106	<b>S. Gatley</b> M. Vazquez O. Rice	Brookhaven National Laboratory, NY “	<b>Ph.D, Principal Investigator</b> <b>M.D, Ph.D, Co-Investigator</b> Ph.D, Co-Worker
N-107	<b>A. Kennedy</b> J. Ware X. Wan J. Guan Z. Zhou J. Stewart J. Donahue	University of Pennsylvania, PA “ “ “ “ “ “	<b>Sc.D, Principal Investigator</b> Ph.D., Co-Worker Ph.D., Co-Worker Ph.D., Co-Worker M.S., Co-Worker M.S., Co-Worker M.S., Co-Worker
N-108 N-113	<b>M. Pecaut</b> G. Nelson A. Smith T. Jones	Loma Linda University, CA “ “ “	<b>Ph.D, Principal Investigator</b> Ph.D, Co-Worker B.S, Co-Worker B.S, Co-Worker
N-109	<b>J. Archambeau</b> G. Nelson X. Mao A. Smith P. Archambeau D. Crockett	Loma Linda University, CA “ “ “ “ “	<b>M.D, Principal Investigator</b> Ph.D, Co-Worker M.D, Investigator B.S, Co-Worker B.S, Co-Worker B.S, Co-Worker
N-110	<b>G. Nelson</b> A. Smith S. Rightnar T. Jones J. Archambeau M. Pecaut X. Mao	Loma Linda University, CA “ “ “ “ “ “	<b>Ph.D, Principal Investigator</b> B.S, Co- Worker B.S, Co-Worker B.S, Co-Worker M.D, Co-Worker Ph.D, Co-Worker M.D, Co-Worker

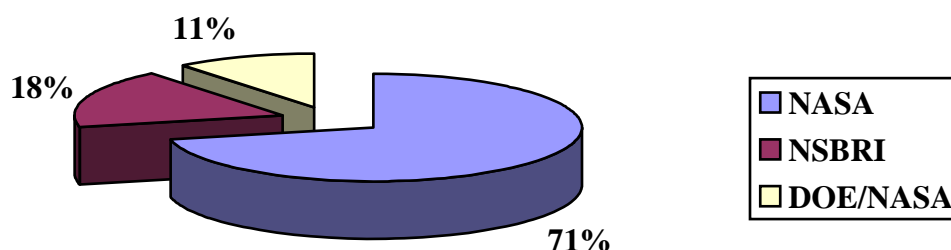
<b>Exp.</b>	<b>Participants</b>	<b>Affiliation</b>	<b>Title</b>
N-89	<b>K. Held</b> H. Yang V. Anzenberg	Massachusetts General Hospital/Harvard Medical School “ “	<b>Ph.D., Principal Investigator</b> Ph.D., Co-Worker B.S., Co-Worker
N-95	<b>M. Story</b> U. Giri	University of Texas, MD Anderson “	<b>Ph.D., Principal Investigator</b> Ph.D., Co-Worker
N-111 N-112	<b>A. Obenaus</b> G. Nelson A. Smith T. Lamp S. Shin	Loma Linda University, CA “ “ “ “	<b>Ph.D, Principal Investigator</b> Ph.D, Co-Worker B.S, Co-Worker B.S., Co-Worker B.S, Co-Worker
N-116	<b>E. Benton</b>	ERIL, CA	<b>Ph.D, Principal Investigator</b>

\*Not Present During Actual Run

## NSRL-2 PARTICIPANTS STATISTICS

<b>PARTICIPANTS</b>	<b>NSRL-2</b>
<b>Ph.D., Principal Investigators</b>	<b>18</b>
<b>M.D., Ph.D., Principal Investigators</b>	<b>1</b>
<b>M.D., Principal Investigators</b>	<b>1</b>
<b>SC. D., Principal Investigators</b>	<b>1</b>
<b>Ph.D., Co-Principal Investigators</b>	<b>3</b>
<b>Co-Workers</b>	
<b>Ph.D.</b>	<b>26</b>
<b>M.D.</b>	<b>3</b>
<b>M.S.</b>	<b>5</b>
<b>B.S.</b>	<b>20</b>
<b>B.S./B.A.</b>	<b>1</b>
<b>M.A.</b>	<b>2</b>
<b>Senior Research Associates</b>	<b>1</b>
<b>Total:</b>	<b>82</b>

## RESEARCH PROJECT SPONSORS:



## **PARTICIPANT INSTITUTIONS**

### **NASA related centers/institutes (2)**

- NASA, Johnson Space Center, TX
- National Space Biomedical Research Institute, TX

### **National Laboratories/Institutes/Centers (3)**

- Brookhaven National Laboratory, NY
- Lawrence Berkeley National Laboratory, CA
- HNRCA, USDA-ARS, MA

### **Universities (9)**

- Loma Linda University, CA
- University of Pennsylvania, PA
- University of Texas M.D. Anderson Center, TX
- Thomas Jefferson University, PA
- Colorado State University, CO
- Columbia University, NY
- University of Maryland, Baltimore County, MD
- Texas A&M University, TX
- Oregon Health and Science University, OR

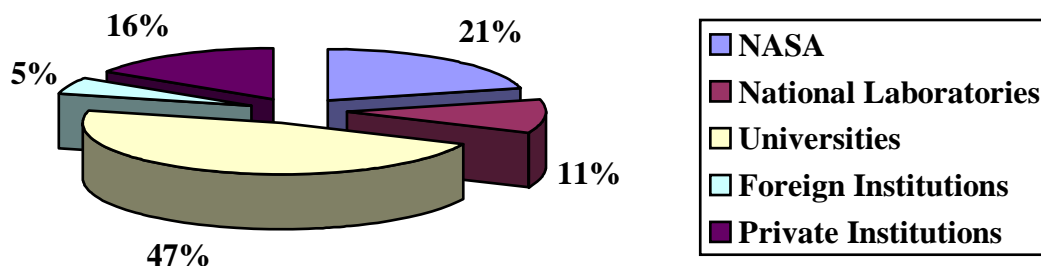
### **Private Institutions (3)**

- Massachusetts General Hospital, MA
- SRI, CA
- ERIL, CA

### **Foreign Institutions (2)**

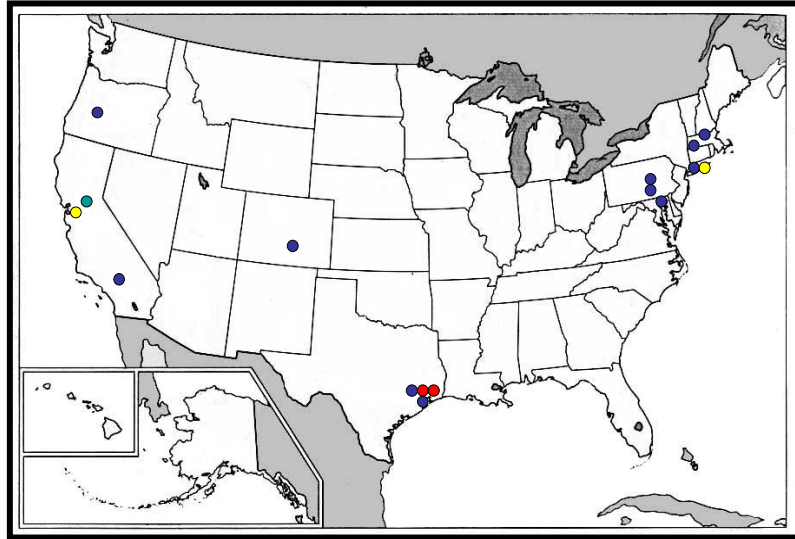
- International Space Radiation Laboratory, Chiba, Japan
- MRC Radiation & Genome Stability Unit, UK

## **INSTITUTIONS STATISTICS:**



## U.S. Participant Institutions and State Distribution

- NASA Related Centers
- National Laboratories
- Universities
- Privates Institutions



### **California**

- Lawrence Berkeley National Laboratory, Berkeley
- Loma Linda University, Loma Linda
- SRI, Menlo Park
- ERIL, San Francisco

### **Colorado**

- Colorado State University, Fort Collins

### **Maryland**

- UMBC, Baltimore

### **Massachusetts**

- HNRCA, USDA-ARS, Boston

### **New York**

- Brookhaven National Laboratory, Upton
- Columbia University, New York

### **Oregon**

- Oregon Health and Science University

### **Pennsylvania**

- University of Pennsylvania School of Medicine, Philadelphia
- Thomas Jefferson University, Philadelphia

### **Texas**

- NASA Johnson Space Center, Houston
- National Space Biomedical Research Institute, Houston
- University of Texas MD Anderson
- Texas A&M University, College Station

## **NSRL-2 SILICON RUN DESCRIPTION**

### **RUN DATES**

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	03/15	0700	03/15	0700
Run end	03/19	2100	03/20	0030
Tuned into cave	03/14	2000	03/15	0545
Beam delivered for Physics				
Si 0.6 GeV/n	03/15	1700	03/15	0830
End run	03/16	1900	03/16	0730
Beam delivered for Biology				
Si 0.6 GeV/n	03/17	0900	03/16	0900
End run	03/19	1600	03/20	0030

### **BEAM TIME DESCRIPTION (hours)**

Total Clock Time	(from 03/15-16 0700 to 03/18-20 0030)	74.0
Total Beam-on time		51.0
Total Beam-off time		23
Beam Time for Biology		
Si 0.6 GeV/n In Vitro Studies	19.5	
Si 0.6 GeV/n In Vivo Studies	4.5	
Si 0.6 GeV/n Physics	12.0	
Sub-total		36.0
Beam Time for Beam Develop.		
Si 0.6 GeV/n	0	
Sub-total		0
Set Up Time		
Si 0.6 GeV/n	13.0	
Sub-total		13.0
Spill Structure		
Si 0.6 GeV/n	2.0	
Sub-total		2.0
Totals		
Contingency T. Planned	5	
Contingency T. Used	5	

## NSRL-2 CARBON RUN DESCRIPTION

### RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	03/22	0700	03/22	0700
Run end	03/23	1900	03/23	2130
Tuned into cave	03/21	2000	03/22	0630
Beam delivered for Biology				
C 0.29 GeV/n	03/22	1300	03/22	1400
End run	03/26	2000	03/23	2030

### BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 03/22 0700 to 03/23 2030)		31.5
Total Beam-on time			28.5
Total Beam-off time			3
Beam Time for Biology			
C 0.29 GeV/n In Vitro Studies	14.5		
C 0.29 GeV/n In Vivo Studies	4.0		
C 0.29 GeV/n Others (gels, testing)	0.0		
Sub-total		18.5	
Beam Time for Physics			
C 0.29 GeV/n	0		
Sub-total		0	
Set Up Time			
C 0.29 GeV/n	7		
Sub-total		7	
Spill Structure			
C 0.29 GeV/n	3		
Sub-total		3	
Totals			31.5
Contingency T. Planned	2		
Contingency T. Used	2		

## NSRL-2 IRON 1 GeV/n RUN DESCRIPTION

### RUN DATES

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	03/24	0700	03/26	2000
Run end	04/09	1700	TBD	TBD
Tuned into cave	03/24	0200	03/26	1500
Beam delivered for Physics				
Fe 1 GeV/n	03/24	1300	03/27	0400
End run	03/25	0200	03/27	1300
Beam delivered for Biology				
Fe 1 GeV/n	03/25	0900	03/27	1330
End run	04/09	1700	04/09	18:30

### BEAM TIME DESCRIPTION (hours)

Total Clock Time	(from 03/26 2000 to 03/29 2200)	162.5
Total Beam-on time		129
Total Beam-off time		16.5
RHIC Fillings		17.0
Fe 1 GeV/n In Vitro Studies	46.5	
Fe 1 GeV/n In Vivo Studies	36.0	
Fe 1 GeV/n Physics	6.5	
Fe 1 GeV/n Beam Development	10.0	
Sub-total		99.0
Set Up Time		
Fe1 GeV/n	28	
Sub-total		28
Spill Structure		
Fe1 GeV/n	2	
Sub-total		2
Totals		129
Contingency T. Planned		
Contingency T. Used		

## **NSRL-2 IRON 0.6 GeV/n RUN DESCRIPTION**

### **RUN DATES**

Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	04/12	1100	04/12	0700
Run end	04/19	2000	04/19	1830
Tuned into cave	04/12	0700	04/12	0700
Beam delivered for Biology				
Fe 0.6 GeV/n	04/12	1100	04/12	1200
End run	04/19	2000	04/19	1830

### **BEAM TIME DESCRIPTION (hours)**

Total Clock Time	(from 04/12 0700 to 04/19 1830)	80.0
Total Beam-on time		69.0
Total Beam-off time		11.0
Fe 0.6 GeV/n In Vitro Studies	14.0	
Fe 0.6 GeV/n In Vivo Studies	37.0	
Fe 0.6 GeV/n Beam Development	4.0	
Sub-total	55.0	
Set Up Time		
Fe 0.6 GeV/n	13.0	
Sub-total	13.0	
Spill Structure		
Fe1 GeV/n	1.0	
Sub-total	1.0	
Totals		69.0
Contingency T. Planned	6.0	
Contingency T. Used	3.5	

## **NSRL-2 TITANIUM 1 GeV/n RUN DESCRIPTION**

### **RUN DATES**

<b>Run dates</b>	<b>Scheduled</b>		<b>Actual</b>	
	<b>Date</b>	<b>Time</b>	<b>Date</b>	<b>Time</b>
<b>Run start</b>	<b>04/20</b>	<b>0700</b>	<b>04/20</b>	<b>0700</b>
<b>Run end</b>	<b>04/22</b>	<b>1800</b>	<b>04/22</b>	<b>1530</b>
<b>Tuned into cave</b>	<b>04/20</b>	<b>0500</b>	<b>04/20</b>	<b>0600</b>
<b>Beam delivered for Biology</b>				
<b>Ti 1 GeV/n</b>	<b>04/20</b>	<b>0900</b>	<b>04/20</b>	<b>0900</b>
<b>End run</b>	<b>04/22</b>	<b>1800</b>	<b>04/22</b>	<b>1530</b>

### **BEAM TIME DESCRIPTION (hours)**

<b>Total Clock Time</b>	<b>(from 04/20 0700 to 04/22 1530)</b>		<b>34.5</b>
<b>Total Beam-on time</b>			<b>34.5</b>
<b>Total Beam-off time</b>			<b>0</b>
<b>Ti 1 GeV/n In Vitro Studies</b>	<b>18.0</b>		
<b>Ti 1 GeV/n In Vivo Studies</b>	<b>2.0</b>		
<b>Ti 1 GeV/n Beam Development</b>	<b>5.0</b>		
<b>Sub-total</b>		<b>25.0</b>	
<b>Set Up Time</b>			
<b>Ti 1 GeV/n</b>	<b>8.0</b>		
<b>Sub-total</b>		<b>8.0</b>	
<b>Spill Structure</b>			
<b>Ti 1 GeV/n</b>	<b>1.5</b>		
<b>Sub-total</b>		<b>1.5</b>	
<b>Totals</b>			<b>34.5</b>
<b>Contingency T. Planned</b>	<b>3.0</b>		
<b>Contingency T. Used</b>	<b>2.0</b>		

## NSRL-2 FINAL RUN DATES

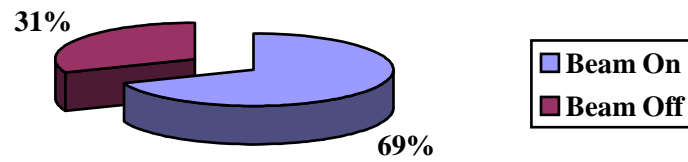
Run dates	Scheduled		Actual	
	Date	Time	Date	Time
Run start	03/15	0700	03/15	0700
Run end	04/22	1800	04/22	1530

## NSRL-2 TOTAL BEAM TIME DESCRIPTION (hours)

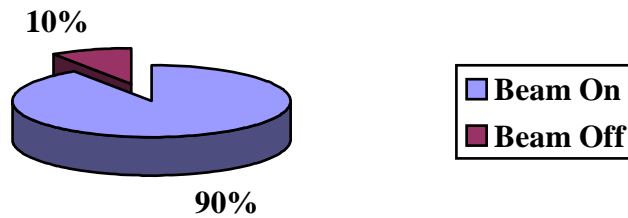
<b>Total Clock Time</b>	<b>(from 03/15 0700 to 04/22 1530)</b>		<b>382.5</b>
<b>Total Beam-on Time</b>			
Si 0.6 GeV/n	51.0		
C 0.29 GeV/n	28.5		
Fe 1 GeV/n	129.0		
Fe 0.6 GeV/n	69.0		
Ti 1 GeV/n	34.5		
<b>Total</b>		<b>312</b>	
<b>Total Beam-off time</b>			
Si 0.6 GeV/n	23.0		
C 0.29 GeV/n	3.0		
Fe 1 GeV/n	16.5		
Fe 0.6 GeV/n	11.0		
Ti 1 GeV/n	0.0		
<b>Total</b>		<b>53.5</b>	
<b>RHIC FILLINGS</b>	<b>17</b>		
<b>Total</b>		<b>17</b>	
<b>Total Beam Time for Exp.</b>			
In Vivo Studies	112.0		
In Vitro Studies	83.5		
Physics	18.5		
<b>Total</b>		<b>214.0</b>	
<b>Beam Time Development</b>	<b>19.0</b>		
<b>Total</b>		<b>19.0</b>	
<b>Beam Time Spill Structure</b>	<b>9.5</b>		
<b>Total</b>		<b>9.5</b>	
<b>Set Up Time</b>	<b>69.5</b>		
<b>Total</b>		<b>69.5</b>	
<b>Totals</b>			<b>312</b>
<b>Contingency T. Planned</b>	<b>26</b>		
<b>Contingency T. Used</b>	<b>19.5</b>		

## DESCRIPTIVE STATISTICS

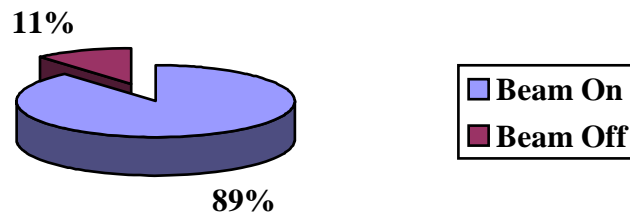
- **SI 600 MEV/N BEAM AVAILABILITY**



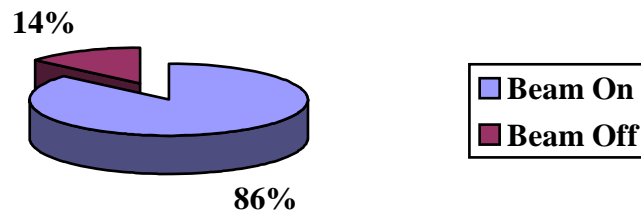
- **C 290 MEV/N BEAM AVAILABILITY**



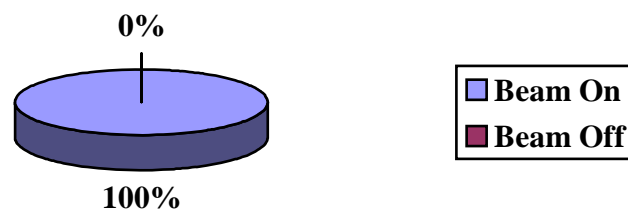
- **FE 1 GEV/N BEAM AVAILABILITY**



- **FE 0.6 GEV/N BEAM AVAILABILITY**

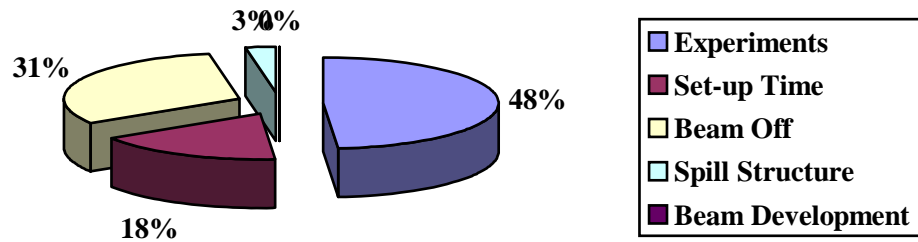


- **TI 1 GEV/N BEAM AVAILABILITY**

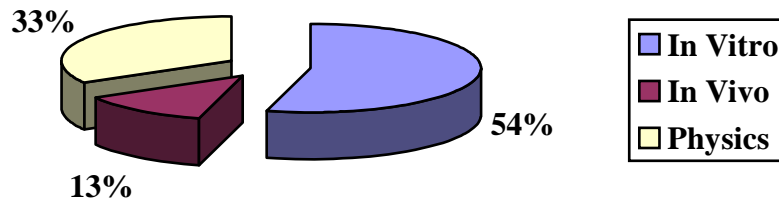


## SILICON ION RUN:

- SI 0.6 GEV/N DISTRIBUTION OF BEAM TIME USAGE:

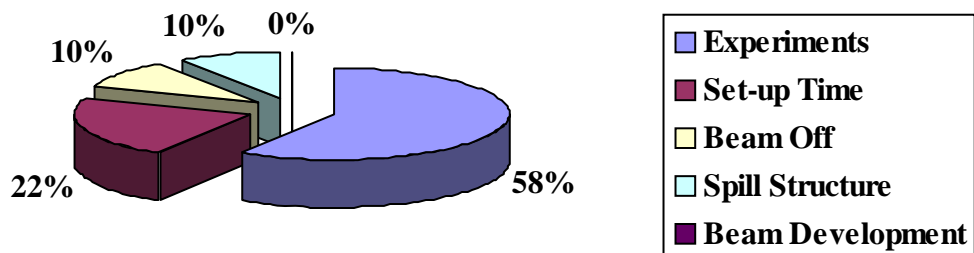


- SI 0.6 GEV/N DISTRIBUTION OF BEAM TIME FOR EXPERIMENTS:

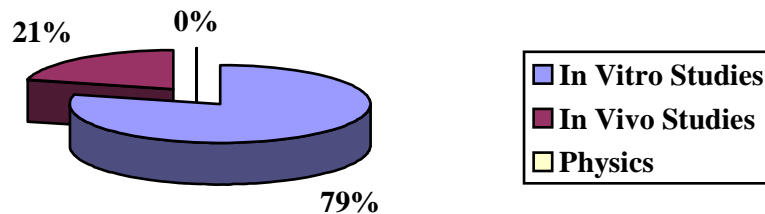


## CARBON ION RUN

- C 0.29 GEV/N DISTRIBUTION OF BEAM TIME USAGE:

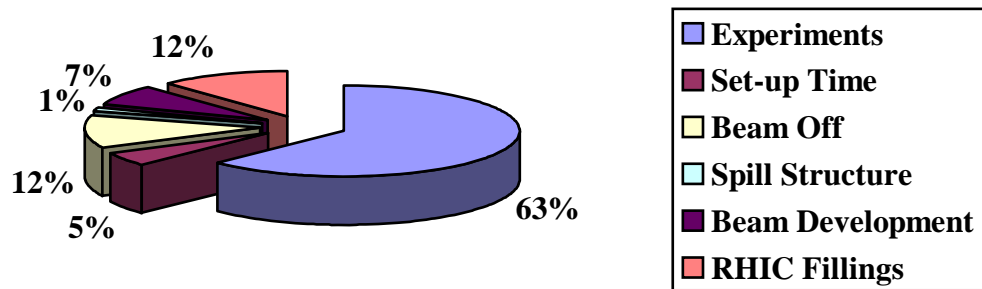


- C 0.29 GEV/N DISTRIBUTION OF BEAM TIME FOR EXPERIMENTS:

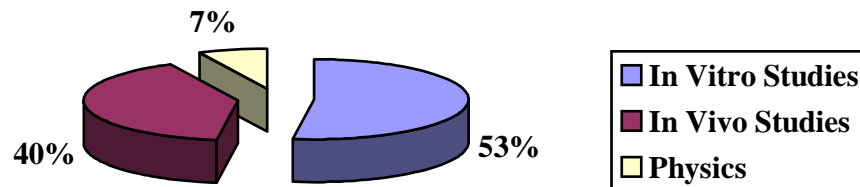


## IRON ION RUN (1 GeV/n)

- FE 1 GEV/N DISTRIBUTION OF BEAM TIME USAGE:

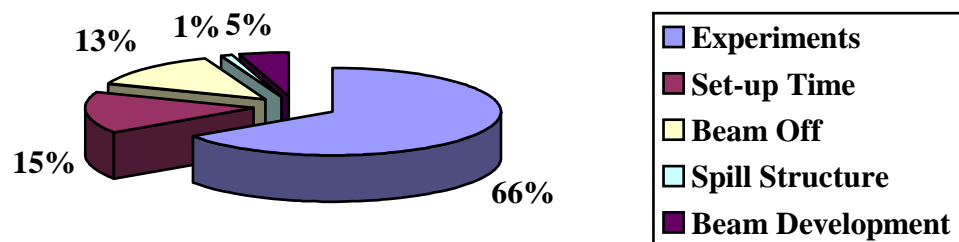


- FE 1 GEV/N DISTRIBUTION OF BEAM TIME FOR EXPERIMENTS:

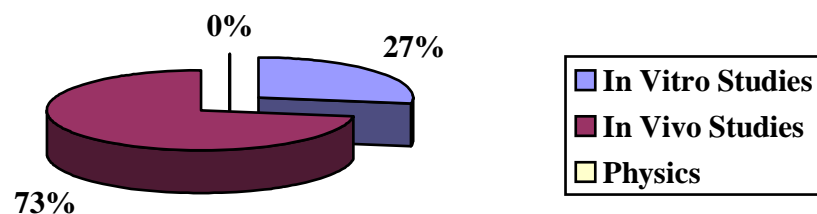


## IRON ION RUN (0.6 GeV/n)

- FE 0.6 GEV/N DISTRIBUTION OF BEAM TIME USAGE:

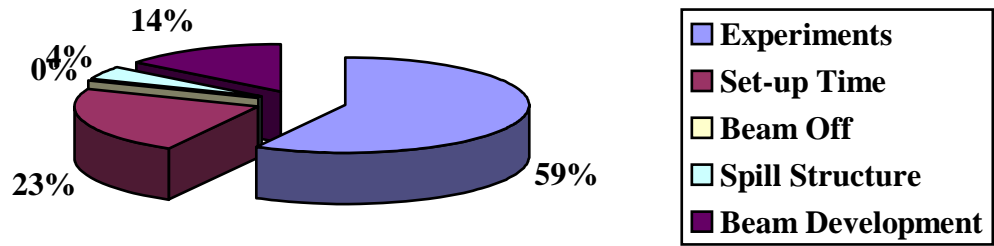


- FE 0.6 GEV/N DISTRIBUTION OF BEAM TIME FOR EXPERIMENTS:

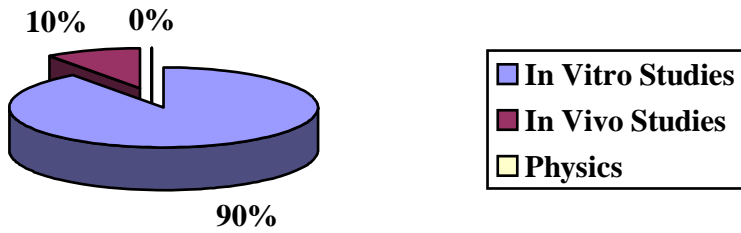


## TITANIUM ION RUN

- TI 1 GEV/N DISTRIBUTION OF BEAM TIME USAGE:

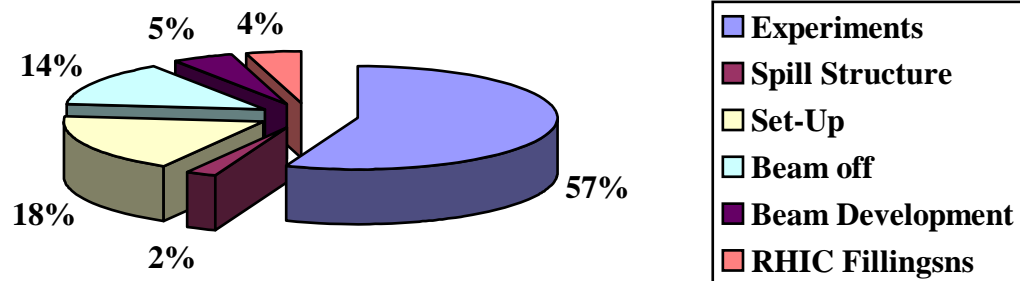


- TI 1 GEV/N DISTRIBUTION OF BEAM TIME FOR EXPERIMENTS:

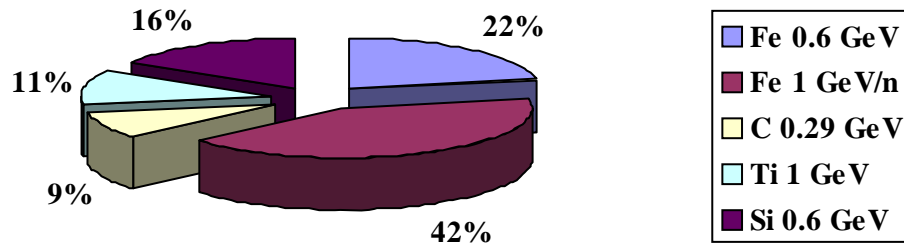


## NSRL-2 TOTAL BEAM TIME SUMMARY

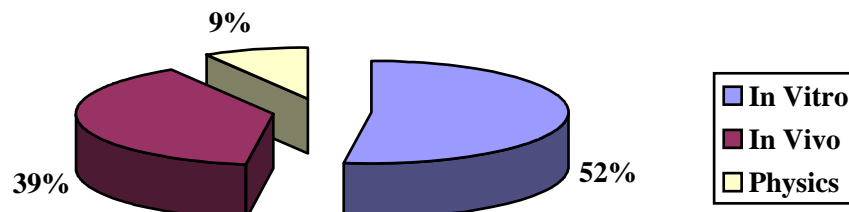
- DISTRIBUTION OF BEAM TEAM USAGE:**



- DISTRIBUTION OF BEAM TIME ON BY SPECIES AND ENERGIES:**



- DISTRIBUTION OF BEAM TEAM FOR BIOLOGY EXPERIMENTS:**



## BEAM CHARACTERISTICS

Ion	<sup>56</sup> Fe <sup>26</sup>		<sup>48</sup> Ti <sup>22</sup>	<sup>12</sup> C <sup>6</sup>	<sup>12</sup> Si <sup>6</sup>
Fluence (particles/cm <sup>2</sup> /sec) Maximum on target Minimum on target	TBD	TBD	TBD	TBD	TBD
Spill Period (sec)	3.0	3.0	3.0	5.4	4.5
Spill rate (spills/min)	20	20	20	20	20
Spill length (msec)	400	400	400	400	400
Particles/spill Maximum Minimum	1000 500	1.0 x 10 <sup>9</sup> 500	4.0 x 10 <sup>8</sup> 500	1.2 x 10 <sup>10</sup> 500	3.0 x 10 <sup>9</sup>
Beam Cut Off Accuracy	~ 0.5 %	~ 0.5 %	~ 0.5 %	~ 0.5 %	~ 0.5 %
Actual Energy (MeV/n) Extracted On Target	600 577	1005 969.1	1007 980	300 293.8	600 580.1
Actual LET on Target (keV/μm)	176.1	151.4	108.1	12.8	53.77
Max. Dose Rate (Gy/min)/ Beam Size (cm x cm) 20 x 20 10 x 10 7 x 7 7 x 30 5 x 5 1 x 1	     0.001	7.0 30.0 50.0	2.5 10.0	4.0 15.0	5.0   25
Total Dose (Gy) Maximum Minimum	0.1	200 0.1	200 0.1	8 0.1	15 0.1

Listed below are the ions extracted and used for biology experiments at NSRL-2. Maximum intensity and dose-rate are shown only. To achieve lower dose-rates, we use the two-jaw collimator at the extraction to reduce the beam flux without changing its shape. Changing the beam size changes the (dose-rate: the dose-rate are measured at the center of the ion-chamber, and only scales roughly with area). Energy at extraction is deduced from frequency measurements in the Booster. Energy at the NSRL target area is obtained from Bragg-curve measurements (done daily during the run). The LET given here is that for the primary ion at the “on target” energy, in water.

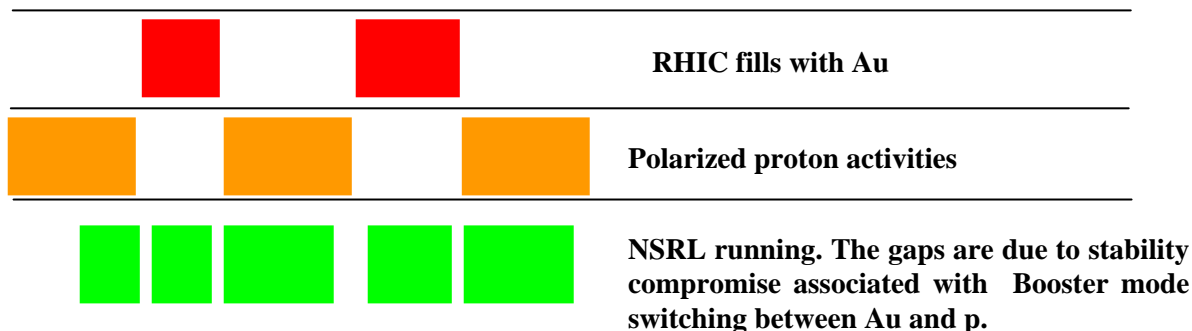
## JOINT NSRL/RHIC OPERATION REPORT

NSRL-2 was the first run carried out alongside RHIC (and BLIP). There were several changes made to the way beam was extracted and scheduled at NSRL and the way access to the target room was provided. These are outlined below, the successes and failures pointed out.

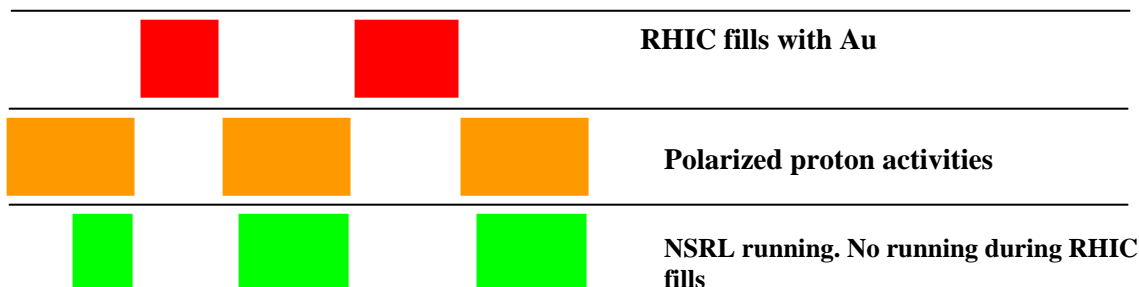
**PPM:** Pulse by Pulse Modulation. This is a mode of operation in which both RHIC and NSRL can run, sharing the Booster and, in principle, not impact each other. It is achieved by creating a Booster Magnet cycle which provides RHIC beam in one part and NSRL beam in another. The NSRL part is “hidden” behind the AGS ramping cycle, during which no use is made of the Booster for RHIC. This cycle is 4.5 seconds long, which is what drives the repetition rate we used this run at NSRL. To achieve PPM, both Tandem sources, one for RHIC (Au) and one for NSRL were used. The two ions used in the sources must be delivered to the Booster at a single rigidity, and the particular rigidity we used was dictated by RHIC’s Au beam. Only a handful of ions are injectable into the booster at this rigidity, so of those used at NSRL during this run only Si and C were available in PPM.

The PPM mode did work well, by itself, but there was more to the story than that. In addition to the two ions in the Booster, RHIC was also preparing for the polarized-proton run. That meant that whenever RHIC was done injecting Au, the AGS started taking protons from the LINAC. We were able to run in PPM mode with the protons, but the mode switch in the Booster caused, at least in the first week or two, unpredictable beam conditions immediately following such a switch, for periods of up to about 30 minutes, until operators and experts could gain understanding and control of the situation. These periods cost dearly in time, as once the conditions change we are compelled to repeat film exposure and calibration, adding another 30 minutes to the unlucky experimenter’s run.

A schematic time-line of a day in the life of NSRL under PPM is shown below.



**Mode Switch:** In this mode, NSRL and RHIC cannot simultaneously use the Booster because the ions used by NSRL cannot be delivered from Tandem to Booster at the same rigidity. This was the condition during the first part of the Fe run. A schematic time-line of a day at NSRL under mode-switching is shown below.



**Access:** Because the Booster was shared with RHIC during NSRL-2, the critical device used to ensure safe access to the target-room was different from the one used during stand-alone runs. When there is no other user of the Booster the way to ensure no beam is extracted into NSRL is to close the beam-stops between the Tandem and the Booster. These stops are small (low energy side of the Booster) and move into position quickly, over a few seconds. Nothing else is changed in the Booster, so beam extraction and transport are not affected, and upon resumption of activities beam conditions are unchanged.

During NSRL-2, the critical device was the D6 magnet, the septum which extracts the beam from Booster into NSRL, along with the associated beam-plug a few meters down stream from the extraction point. Both are slow-changing devices, which must be changed in sequence, and since the D6 is the extraction magnet, additional steps must be taken to ensure beam conditions come back to the ones which existed before access. This lead to a much longer access time than what we experienced in previous runs, and what we expect in all stand-alone ones. The motion of the beam plug takes 20 seconds in each direction. The D6 ramping up requires about 5 seconds per 1000 A (at 1000 MeV/n, the D6 set point is over 4500 A). During the first week there were problems getting the D6 magnet to return to its previous set point reliably before extraction started, so early in the exposure following an access the beam was not well under control. This was alleviated during the first week, and the users experienced no more such problems in the remainder of the run. However, the time delay in access and recovery of beam continued to be a source of frustration for the users.

**Iris Scanner:** For NSRL-2 a new up-graded version of the iris-scanner was installed. The new iris-scanner worked much faster and with higher much higher successful recognition rate than the old one. However, experience four crashes of the system which required rebooting, an action which at the time could only be carried out by a member of the security group. The problem appears to be a software problem, and is being dealt with by the group in consultation with the manufacturer. In addition, there are now more people who are allowed to reboot the system, if the need arises.

### **Users comments**

The consensus among users that were schedule during he week of March 27<sup>th</sup> to April 1<sup>st</sup> was the most difficult run ever from the point of view of biologist and physics users. There were at least 2-3 fills for RHIC per day with little notice with the additional problem of the need of re-tuning the beam after RHIC was filled. Also, out of those five days of running, three of them had problems with the Tandem. It was suggested not running the same types of experiments if/when NSRL run with RHIC again. At least two users (Benton and Vazquez) lost a set of experiments due to RHIC related interruptions. It was also evident the need of developing and implements a digital camera system to measure the uniformity of the beam. This would add resolution and save time during the set up process. The Long-Term Support Facility (LTSF) at Medical Dept. delivered and up-graded suit of laboratories and offices improving substantially the users support. Also, some rules were flexibilized concerning sample transportation between LTSF and NSRL.

## NSRL-2 EXPERIMENTERS AND RUN STATISTICS

Exp. ID	Principal Investigator	Ion & Energy	Beam Time Approved	Beam Time Used	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
<b>B-3</b>	Cucinotta	Si, 0.6 GeV/n	3	4.5	10-200	20-50	28
		Fe, 0.6 GeV/n	3	4.0	10-200	20-50	30
		Ti, 1 GeV/n	3	3.5	4-60	5-16	81
<b>B-7</b>	Rabin	Si, 0.6 GeV/n	7	4.5	25-300	100-200	93
		Fe, 0.6 GeV/n	6	6.5	5-150	30-150	90
<b>B-10</b>	Chang	Fe, 1 GeV/n	15	16	2-50	4-20	48
		Fe, 0.6 GeV/n	3	3	50-200	100-200	51
<b>B-52</b>	Gewirtz	Si, 600 MeV/n	2.5	2.5	NA	NA	NA
		Fe, 1 GeV/n	3.5	3.5	"	"	"
		Ti, 1 GeV/n	2.5	2.5	"	"	"
<b>N-64</b>	Vazquez	Fe, 1 GeV/n	4	4.5	30-240	30-100	120
		Fe, 0.6 GeV/n	4	2.0	"	"	120
<b>N-65</b>	Vazquez	Si, 600 MeV/n	3	2.5	15-200	60	30
		C, 290 MeV/n	3	2.0	"	"	40
		Fe, 1 GeV/n	3	6.5	"	"	50
		Fe, 0.6 GeV/n	3	2.5	"	"	40
<b>B-67</b>	Blakely	Fe, 0.6 GeV/n	4	3.0	10-100	8.23-105	12
		Ti, 1 GeV/n	4	1.5	10-100	9.94-100	12
<b>B-73</b>	Sutherland	Si, 600 MeV/n	4.3	4	50-2000	20-2000	NA
		Fe, 1 GeV/n	4.5	2.5	NA	NA	NA
		Ti, 1 GeV/n	4.3	3	NA	NA	NA
<b>B-75</b>	Ford	Fe, 1 GeV/n	3	3.5	NA	NA	32
<b>B-76</b>	Green	C, 290 MeV/n	2	2.0	10-50	50	17
		Fe, 1 GeV/n	2	1.0	10-50	50	6
<b>N-86</b>	Wang	Fe, 1 GeV/n	5	5	100-2000	100	64
<b>B-88</b>	Sutherland	Si, 600 MeV/n	2.5	4.5	NA	NA	NA
		Fe, 1 GeV/n	3.5	3.5	NA	NA	NA
		Ti, 1 GeV/n	2.5	2.5	NA	NA	NA
<b>N-89</b>	Held	C, 290 MeV/n	3.1	4	0.1-500	Up to 200	32
		Fe, 1 GeV/n	5.7	5	0.1-500	Up to 200	34
		Ti, 1 GeV/n	4	5	0.1-500	Up to 200	27
<b>N-91</b>	Rydberg	Fe, 1 GeV/n	9	6.5	5-2000	10-230	94
<b>N-95</b>	Story	Fe, 0.6 GeV/n	5	5.5	25-200	100-300	41
<b>N-96</b>	Nelson	C, 290 MeV/n	2	4	10-2500	25-200	20
<b>N-97</b>	Kronenberg	Fe, 1 GeV/n	8	8	100-200	50-85	96
<b>N-102</b>	Hall	Fe, 1 GeV/n	3	1	10-300	50	6
<b>N-104</b>	Weil/Ullrich	Fe, 1 GeV/n	7.5	7.5	10-100	5-35	46
<b>N-105</b>	Chatterjee	Fe, 1 GeV/n	1.0	3.0	100-400	10-80	9
		Fe, 0.6 GeV/n	1.0	2.5	50-600	20-110	15
<b>N-106</b>	Gatley	Fe, 1 GeV/n	4.0	4.0	120-240	100	60
<b>N-107</b>	Kennedy	C, 290 MeV/n	3.5	3.5	10-800	40-250	32
		Fe, 1 GeV/n	7.0	3.5	"	40-120	88
<b>N-108</b>	Pecaut	Fe, 0.6 GeV/n	3.0	2.0	0-400	100-200	18
<b>N-109</b>	Archambeau	Fe, 0.6 GeV/n	18.0	13.0	NA	NA	NA
<b>N-110</b>	Nelson	Fe, 0.6 GeV/n	4	4.5	50-400	150	40
<b>N-111</b>	Obenaus	Fe, 0.6 GeV/n	3	2.5	100-400	200	45
<b>N-112</b>	Obenaus	Fe, 0.6 GeV/n	3	2	50-400	150	40

Exp. ID	Principal Investigator	Ion & Energy	Beam Time Approved	Beam Time Used	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples
N-113	Pecaut	Fe, 0.6 GeV/n	3	2	0-400	100-200	18
N-116	Benton	Fe, 1 GeV/n	12	6.5	NA	NA	NA
		Si, 0.6 GeV/n	12	12			
Totals			231.9	214.0	0.1-2000	0.1-2000	~1725

## EXPERIMENTAL SAMPLES AND ENDPOINTS

Exp.	Participants	Samples	Endpoints
B-7	Effects of Exposure to Heavy Particles <b>B. Rabin (PI)</b>	Sprague Dawley Rats	Behavioral paradigms and neurochemistry
B-10	Charged Particle Radiation-induced Genetic Damage in Transgenic Mice <b>P. Chang (PI)</b>	LacZ transgenic mouse with different p53 genotypes	Mutation frequency, micronucleous formation and chromosomal aberrations
B-3	Heavy Ion Induced Chromosome Damage and Biomedical Countermeasures <b>F. Cucinotta (PI)</b>	Human Lymphocytes, Human Fibroblasts, and Chinese Hamster cells	Chromosome damage, structure effects on DNA double strand break induction and repair.
B-52	Effect of Deep Space radiation on Human Hematopoietic Stem Cells. <b>A. Gewirtz (PI)</b>	Human bone marrow cells	DNA complex damages, DNA replication and apoptosis, gene expression
B-64	Risk Assessment and Chemoprevention of HZE-Induced CNS Damage. <b>M. Vazquez (PI)</b>	NT2 human neural stem cells, oligodendrocytes	Survival, apoptosis, gene expression.
B-65	CNS Damage and Countermeasure. <b>M. Vazquez (PI)</b>	C57Bl/6 Mice	Behavioral Testing: Locomotor activity and Morris Water Maze. Neurochemistry.
B-67	Lens Epithelium and Proton-Induced Cataractogenesis. <b>E. Blakely (PI)</b>	Human lens epithelial cells	RNA or protein analyses
B-73	DNA damage clusters in low level radiation responses of human cells. <b>B. Sutherland (PI)</b>	T7 DNA, Human monocytes Supercoiled DNA	DNA damage cluster induction and repair at the molecular and cellular levels
B-75	Low Dose Response of Respiratory Cells in Intact Tissue and Reconstituted Tissue Constructs. <b>John Ford (PI)</b>	Rat tracheal tissue	Immunohistochemistry to visualize repair-associated proteins and spatially correlated patterns of apoptosis
B-76	Response of Thyroid Tissue Units to Space-Like Radiation Fields. <b>Lora Green (PI)</b>	FRTL-5 cells (rat thyroid)	RNA gene arrays, Analysis of fixed tissue/cells for specific quantification of structural components
N-86	Cellular Response to High Energy Particle Exposures. <b>Y. Wang (PI)</b>	GM 847 and ATR-kd human fibroblasts	Clonogenic survival, G2 checkpoint, DNA replication, CHK1 phosphorylation and DNA repair.

<b>Exp.</b>	<b>Participants</b>	<b>Samples</b>	<b>Endpoints</b>
N-88	Complex Space Radiation-induced DNA damage Clusters in Human Cell Transformation: Mechanisms, relationships and Mitigation. <b>B. Sutherland (PI)</b>	Human normal fibroblasts	DNA damage cluster and transformation
N-89	Induction of Bystander Effects by High LET Radiation in Cells <b>K. Held (PI)</b>	Human keratinocytes and fibroblasts	Micronuclei formation, expression of p21 and foci formation of $\gamma$ H2AX
N-91	Repair of HZE-induced DNA Double Strand Breaks and PCC Breaks. <b>B. Rydberg (PI)</b>	HeLa cells, CHO cells and xrs6 cells	DSB determination, PCC and bystander effects
N-96	Gene Expression in the Nematode <i>C. Elegans</i> Following Irradiation with Charged Particles. <b>G. Nelson (PI)</b>	Nematode <i>C. elegans</i>	Gene expression by microarray
N-95	Gene Expression Profile Analysis. <b>M. Story (PI)</b>	Human fibroblast cell lines	Gene expression by microarray studies
N-97	Comparative Analysis of Fe ion-induced Autosomal Mutations <b>A. Kronenberg (PI)</b>	Mouse kidney epithelial cells, F1 hybrid mice	Cell killing and mutation at the Aprt locus Using in vivo and in vitro models
N-102	Exposure of Mouse Cells to Graded Doses of One GeV/nucleon Fe(56) Ions. <b>E. Hall (PI)</b>	Thymocytes from wild type knock out mice	Apoptosis assays
N-104	Radiation Leukemogenesis <b>M. Weil/R. Ullrich (PI's)</b>	CBA/CaJ strain mice	Determination of RBE for the induction of AML using slope constants
N-105	Predicted and Observed Dose-Responses for Simple and Complex Chromosomal Aberrations after Exposure of Human Cells to HZE Radiations: Effects of Beam Filtration. <b>A. Chatterjee/J. Bedford (PI's)</b>	GM2149 low passage normal human fibroblasts	FISH Chromosome painting, chromosomal aberrations
N-106	MicroPET Studies of Brain Damage by Heavy Ion Particles. <b>S. Gatley (PI)</b>	Rats	Neurochemical analysis, MicroPET imaging
N-107	Effects of L-Selenomethionine and other Agents on HZE Particle Radiation Induced Cell Killing and Malignant Transformation in vitro. <b>A. Kennedy (PI)</b>	Htori-3 cells (Human Thyroid Epithelial Cells)	Radioprotective effects of L-selenomethionine (SeM), immunofluorescence assays, colony formation
N-108	Progressive Alterations of Central Nervous System Structure and Function Are caused by Charged Particle Radiation. <b>M. Pecaut (PI)</b>	APP23 Transgenic Mice	Neuronal excitability, membrane and synaptic properties, local circuit interactions, synaptic plasticity, using electrophysiology techniques

<b>Exp.</b>	<b>Participants</b>	<b>Samples</b>	<b>Endpoints</b>
N-109	Non-Invasive Assessment of Neuropathology Following CNS Radiation Exposure. <b>J. Archambeau (PI)</b>	Sprague Dawley Rats	Endothelial cell loss, DNA double strand breaks, BrdU labeling index, dose response of microvessels in rat retina, brain cortex, and white matter
N-110	Charged Particle Irradiation Causes a Progressive Loss of Cells and a Remodeling of CNS Tissue as a Function of Dose, Time, and LET. <b>G. Nelson (PI)</b>	C57BL/6 Mice	Immunohistochemical analysis, stereology <i>in situ</i> , immunocytochemistry
N-111	Non-Invasive Assessment of Neuropathology Following CNS Radiation Exposure. <b>A. Obenaus (PI)</b>	Sprague-Dawley Rats	MRI and spectroscopy to assess altered tissue characteristics, image analysis, general histology, immunohistochemistry, phagocytic cell quantification, SWI processing
N-112	Charged Particle Alterations of the Functional Output of the Brain as a Function of Dose, Time, and LET <b>A. Obenaus (PI)</b>	C57BL/6	EEG Recordings, In Vitro brain slice preparation, Extracellular recordings and Long Term Potentiation, Quantitative estimates of venous CBV
N-113	The Effects of Charged Particle Radiation on the CNS Response to an Immunological Stressor. <b>M. Pecaut (PI)</b>	C57BL/6	Histological Analysis of the hippocampus
N-116	Benchmark Analysis and Evaluations of Materials for Shielding/Radiation Shielding Properties of Multifunctional Spacecraft. <b>E. Benton (PI)</b>	Assorted Target Shielding Materials	Beam measurements using TEPC, CR-39 PNTDs, and Liulin MDU

## List of personnel that participated in the planning, organization and execution of NSRL-2 run

### BNL Management:

- Laboratory Director: **Chaudri**
- Associate Director for High Energy and Nuclear Physics: **Tom Kirk**
- Associate Laboratory Director for Life Sciences: **Helene Benveniste**

### NASA Management:

- Headquarters: **Walter Schimmerling, David Tomko**
- JSC: **Frank Cucinotta, Frank Sulzman, Barbara Corbin**

### Scientific Advisory Committee:

- **Betsy Sutherland** (Chair), BNL
- **Louis Pena**, BNL
- **Richard Setlow**, BNL
- **Les Braby**, PNL
- **Charles Geard**, Columbia University
- **Kathy Held**, MIT

### Collider Accelerator Department-AGS

- Chairman: **Derek Lowenstein**
- Deputy Chairman: **W.T. Weng**
- Associate Chair of Operations: **A.J. McNerney**
- Experimental Planning and Support Head: **Philip Pile**
- Associate Chair for ESHQ: **Ed Lessard**
- ESHQ Division Head: **Ray Karol**
- ESH Coordinator: **Asher Etkin**
- Facility Support Representative: **Chuck Schaefer / Henry Kahnhauser**
- Environmental Coordinator: **Joel Scott**
- Training and Procedures Manager : **John Maraviglia**
- Main Control Room: **Peter Ingrassia**
- Work Control Manager: **Peter Cirnigliaro**
- BNL Laser Safety Officer: **Chris Weilandics**
- Experimental Safety Review Committee: **Yousef Makdisi (Chair)**
- Radiation Safety Committee: **Dana Beavis (Chair)**
- Accelerator Safety Review Committee: **Woody Glenn (Chair)**
- ALARA Committee: **Chuck Schaefer (Chair)**
- Associate Chair for ES&H/Q.A: **E. Lessard**
- Accelerator Division Head: **Thomas Roser**
- Chief Electrical Engineer: **J. Sandberg**

- Chief Mechanical Engineer: **J. Tuozzolo**
- Accelerator Physicist lead by: **Leif Aherns**
- Tandem Group leader: **Peter Thieberger**
- Physics Support: **Yusef Makadisi**
- CAD Components and instrumentation support: **David Gassner**
- AGS Radiation Safety Committee: **Ken Reece**
- C-A Dept Training Manager: **John Maraviglia**
- AGS Control Section lead by: **Don Barton**
- Liaison Engineering Group lead by: **David Phillips**
- Liaison physicist: **Adam Rusek**
- RHIC&AGS Users Center: **Susan White-DePace, Angela Melocoton**
- Mechanical Service Technicians led by: **Fred Kobasiuk**
- Survey Group led by: **Frank Karl**
- Beam Service Technicians led by: **Paul Valli**
- Electronic Service Technicians led by: **Bill Anderson**
- AGS Instrumentation Group led by: **Pete Stillman**
- AGS Main Control Room and Operations led by: **Pete Ingrassia**
- **AGS MCR Operation Coordinators:**
  - Jim Jamilkowski**
  - Greg Marr**
  - Sanjee Abeytunge**
  - Jennifer Kozak**
  - Brian van Kuik,**
  - Travis Shrey**
- AGS Electricians led by **Bill Softye**
- AGS Riggers led by: **Nick Cipolla**
- Carpenter and Welder Support Service and Technical Support led by: **Roger Hubbard**

#### **Dosimetry:**

- **Don Lazarus**
- **Adam Rusek**
- **I-Hung Chiang**
- **Kin Yip**
- **Peter Oddo**
- **Bart Frak**

### **Medical Department:**

#### **NASA LTSF TEAM:**

- **Medical Liaisons: Marcelo E. Vazquez, Peter Guida**
- **Technical support: Bea Pyatt, Stacey Russell, Adele Billups**
  - Dept. Chair: **John Gatley**
  - Building Manager: **Chris Harris**
  - Administration: **Denise White and Donna Russo**
  - Animal Care Facilities: **Maryann Kershaw, Kerry Bonti, Patricia Leone**
  - Training Coordinator: **Ann Emrick**
  - **RCD**
    - Kay Conkling
    - Dennis Ryan
    - Deana Buckallew
    - Jim Williams
    - Bob Colichio

### **Plant Engineering:**

- BLAF Custodian, **P. Abrams**
- Plumbers: **B. McCafferty**
- Painters/Carpenters: **B. Laakmann**
- Electricians: **T. Baldwin**

### **Biology Department:**

- Chairman: **Carl Anderson**
- Biology Liason: **Betsy Sutherland**
- Technical Support: **Mamta Naidu, Debasish Roy, Jim Jardine**
- Cesium Source Manager: **Richard Sautkulis**